SaskPower

September 26, 2008

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
State Capitol
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: SaskPower Proposal No. 2008-SCR-001
Entitled "Long-term Assessment of Selective Catalytic Reduction Reactor Slip Stream Performance for Utilities Burning Lignite Coal"

Please find enclosed three (3) copies of the proposal that addresses a research project that has been formulated by Saskatchewan Power Corporation (SaskPower) and Babcock & Wilcox (B&W). A cheque is also enclosed in the amount of $100 for the application fee. The purpose of the proposed project is to assess long-term performance of selective catalytic reduction (SCR) technology over two years on a coal-fired boiler firing Fort Union lignite. Limited slip stream tests performed in the USA have identified potential operating concerns with SCR reactors where lignite is fired. The proposed project will address the lack of longer term testing to formally assess performance.

SCR technology has been widely employed across North America in non-lignite coal-fired boiler applications. Limited slip stream tests in the USA identified potential operating concerns with SCRs where lignite is fired; however, no long-term assessments have been carried out. It is economically critical that potential concerns be identified and addressed in advance, before SCR technology is installed full scale by North Dakota utilities in lignite-fired boiler applications. The test work, which is described in more detail in the enclosed proposal, will involve an approximately 1000 ACFM slip stream SCR reactor, operated and monitored for 16,000 hours at SaskPower's Poplar River Power Station. At the conclusion of the testing, valuable data will be available on the long-term viability of SCR reactors where Fort Union lignite is fired. Poplar River burns a Fort Union lignite coal, meaning results will be applicable to coals burned in North Dakota plants.

The total cost of completing this project is estimated at $1,050,000. The bulk of the funding will be provided by SaskPower and B&W. For the remaining funding, SaskPower is requesting $200,000 from NDIC.

If you have any questions, you may reach me by phone at (306) 566-2290, by fax (306) 566-3348, or by email at dsmith@saskpower.com . We thank you for your past support of research at SaskPower and look forward to working with you on this project.

Sincerely,

Dave Smith
Project Leader, Environmental Initiatives

Garner Mitchell
VP Power Production

DWS/gra

Enclosures

c/enc: Jeff Burgess, Lignite Energy Council
Ron Ojanpera, Babcock & Wilcox Canada Ltd.
Conway Nelson, SaskPower

LONG -TERM ASSESSMENT OF SELECTIVE CATALYTIC REDUCTION REACTOR SLIP STREAM PERFORMANCE FOR UTILITIES BURNING LIGNITE COAL

Saskatchewan Power Corporation Proposal No. 2008-SCR-001

Submitted to:

Karlene Fine

North Dakota Industrial Commission
State Capitol
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Proposal Amount: $200,000

Submitted by:
Dave Smith

Environmental Initiatives – Operations Support
Saskatchewan Power Corporation
2901 Powerhouse Drive
Regina, SK S4N 0A1

Dave Smith, Project Leader

Garner Mitchell, VP Power Production

September 26, 2008

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ABSTRACT

North American utilities must be prepared for emissions regulations requiring substantial reductions in nitrogen oxides (NO_X). Selective catalytic reduction (SCR) has been widely used to control NO_X. However, limited slipstream testing of SCR on coal-fired boilers burning Fort Union lignite fuels have identified serious operating concerns.

In its 2008 technical feasibility analysis of SCR for North Dakota lignite, the North Dakota Department of Health (NDDH) concluded that pilot scale testing would be required to address unresolved problems with adapting SCR technology to a unit firing North Dakota lignite. Among the main problems identified by NDDH for applying SCR to lignite units compared to others were more severe catalyst plugging and deactivation, shorter catalyst operating life, and stickier, potentially more abrasive ashes.

The proposed project will assess the performance of SCR with lignite flue gases over a period of 16 000 operating hours, or two years. Approximately 1000 ACFM of flue gas will be extracted from the boiler economizer outlet to pass through the slipstream SCR reactor. Through regular monitoring of flue gas and the condition of catalyst layers, long-term performance will be assessed. Operating concerns will be identified and recommendations will be made for catalyst application to lignite coal-fired boilers.

The proposed team for this project includes SaskPower, which will serve as the site host at its Poplar River Power Station Unit 1; Babcock & Wilcox, which will oversee the test program plus design and provide the project SCR reactor; and NDIC.

The total cost of the proposed project is $1,050,000, of which SaskPower will contribute $700,000 and Babcock & Wilcox Canada Ltd. will contribute $150,000. SaskPower is requesting that NDIC provide $200,000 toward the proposed work.

PROJECT SUMMARY

Nitrogen oxides (NO_X) are reduced through combustion management or post-combustion control. It is anticipated that combustion management by itself will not be sufficient to meet NO_X reduction requirements in the future. Selective catalytic reduction (SCR) technology is a form of post-combustion NO_X control that has been widely employed by coal-fired utilities. The United States Environmental Protection Agency (US EPA) calls for application of the Best Available Control Technology (BACT) under the New Source Performance Standards and the Best Available Retrofit Technology (BART) for stationary combustion units of a certain age. Generally, the BACT and BART for NO_X control is SCR. Other regulatory drivers that could result in utilities installing SCR on their units include efforts to reduce regional haze and progressively more strict limits on ambient levels of fine particulates and ozone.

Limited slip stream tests performed to date with Fort Union lignite have identified potential concerns with operating SCR reactors, resulting in uncertainty for utilities assessing the technology in anticipation of future regulations requiring further NO_X reduction. The purpose of the proposed project is to conduct a long-term, two-year slipstream assessment of SCR technology on a coal-fired boiler burning Fort Union lignite.

The work under this project will use flue gas from SaskPower's Poplar River Power Station Unit 1, which burns Fort Union lignite. Poplar River was the host site for the NDIC-supported projects Phases II & III of Mercury Control Technologies Burning Lignite Coal. In these previous projects SaskPower constructed its Emissions Control Research Facility (ECRF) to test a continuous slipstream of flue gas that could be taken

from either unit of Poplar River. Flue gas monitoring equipment and data collection and control capabilities installed at the ECRF will be available for this project. Additional monitoring equipment will be acquired to ensure that the test work is properly conducted. SaskPower field personnel at the ECRF with the support of SaskPower technical staff will conduct the test work.

B&W will use its extensive experience in SCR to design and supply a suitable reactor system for this project. SaskPower will arrange for tying in this unit to the appropriate point of the Unit 1 flue gas stream. B&W will develop the detailed test plan required for this work and provide the overall technical coordination of the program.

During the test, flue gas will be extracted from the boiler economizer outlet and pass through the slip stream SCR reactor for 16,000 operating hours. Selected logs of SCR catalyst will be inspected, removed, and replaced every 4000 operating hours. Pertinent operational parameters, such as unit load and flue gas characteristics, will be monitored and recorded to allow for quantitative evaluation of the technology. The test plan, when finalized, will include field testing with ammonia injection. At the conclusion of the test, long-term operating concerns will be identified and recommendations will be made for catalyst application to lignite coal-fired boilers.

Because the test work in the proposed project will be conducted on a continuous slipstream from an existing coal-fired unit burning Fort Union lignite, the results from this project will be particularly representative of SCR performance of North Dakota units firing Fort Union lignite. The information gained from this project will allow lignite-fired utilities to assess the technology with greater confidence.

PROJECT DESCRIPTION

Project Background Summary

Although SCR has been deployed on various coal-fired generating units to control NO_X emissions to required limits, test work up to now has raised concerns about the compatibility of SCR with flue gases resulting from the combustion of Fort Union lignite. The US EPA requires BACT for new units and BART for existing units of a certain age, for which NO_X control generally means SCR. Therefore, more effort is required to determine how SCR can be successfully installed at units firing Fort Union lignite. B&W has developed a project plan to address this need based on its extensive experience in commercial SCR applications and similar slipstream programs designed by B&W that have been performed elsewhere.

Description of Proposed Testing

The proposed project is focused on assessing long-term performance of SCR technology on coal-fired boilers firing Fort Union lignite. Limited slip stream tests have identified potential operating concerns with operating SCR reactors with Fort Union lignite flue gases. The proposed project will address the lack of longer term testing to formally assess performance. An SCR reactor will be fed a continuous slipstream of flue gas from SaskPower's Poplar River Power Station Unit 1. A proposed test period of two years (16,000 operating hours) with ongoing flue gas monitoring and periodic inspection of SCR catalyst logs will be used to ensure that operating issues that could arise in future full-scale SCR installations on units firing Fort Union lignite are properly identified and evaluated.

Project Objectives

The objective of this project is to carry out a two-year test of SCR technology on flue gas from a Fort Union lignite-fired boiler to identify and assess operating issues and evaluate performance. More specifically, the project will allow the participants to determine:

- The optimum temperature for SCR operation with Fort Union lignite flue gases based on initial parametric tests where reactor temperature is varied;
- Changes in catalyst pressure drop over time, thus indicating the extent of plugging;
- The extent of NO_X reduction achieved by the catalyst over time through monitoring of NO_X levels at the inlet and outlet of the catalyst;
- The nature of the material that may be depositing on the catalyst through appropriate analyses of catalyst logs recovered from the slipstream reactor,
- The extent of ammonia slip and SO_3 formation by flue gas analyses done over the course of this project

In the event that future environmental regulations require reduced NO_x emissions, the results of this program would provide valuable design and operating information on the application of SCR when firing Fort Union lignite fuels.

Host Unit

Flue gas will be continuously fed to the slipstream SCR test unit by flue gas from SaskPower's Poplar River Power Station Unit 1. Flue gas from this unit has been used to evaluate mercury removal by activated carbon injection from Fort Union lignite flue gas in previous projects sponsored by NDIC. Table 1 gives detailed specifications of the unit on which the slip stream SCR will be installed.

Table 1. SaskPower Poplar River Power Station Unit 1 Specification

Component	Specifications/Notes
Coal Combusted	Fort Union lignite, Poplar River Mine
Boiler	CE corner, tangential-fired boiler
Load	310 MW
Mills	6 mills (Raymond – CE 1003)
Uncontrolled NO_X	0.6 lb/MMBtu
Primary Air Heater Inlet Temperature	700 - 800^{O}F
Secondary Air Heater Inlet Temperature	600 – 700^{O}F

Test Approach for Slip Stream Tests

Approximately 1000 ACFM of flue gas will be extracted from the boiler economizer outlet and pass through the slip stream SCR reactor designed and supplied by B&W. To allow the test team to adjust the reactor inlet temperature for performance testing, the slipstream design will include provision for mixing flue gas extracted from the primary and secondary air heater inlets ahead of the SCR reactor. This will allow for more control over the flue gas temperature entering the SCR reactor.

The reactor will consist of an approximately one-foot duct, approximately 30 feet in length, with an ammonia injection grid upstream of three to four catalyst layers. A small fan will be used to overcome the pressure drop across the SCR duct. The design will also include provision such that the catalyst layers will be accessible for inspection, removal, and replacement.

B&W personnel will inspect the reactor at 4000 hour intervals. Along with unit load, inlet and outlet NO_x, sulphur dioxide (SO_2), and oxygen will be continuously monitored and logged throughout the two-year test period. Reactor inlet gas temperature, pressure drop across SCR catalyst layers, and gas flow through the reactor will also be monitored and logged regularly.

Catalyst logs from the front two catalyst layers will be removed and replaced every 4000 operating hours while the back layers will be left in place for the duration of the test. Removed logs will be sent for lab analysis. The test plan, when finalized, will include testing with ammonia injection while continuously monitoring NO_x concentrations in flue gas before and after the catalyst and measuring ammonia slip after the catalyst.

Test Equipment

System control, operational monitoring, data logging

Signals from the test equipment installed for this project will be sent to the existing system control and data logging system installed at the ECRF located adjacent to Poplar River Power Station. This will allow the ECRF staff to monitor and control the project test systems. ECRF staff will also be available for periodic performance testing.

Continuous Emissions Monitors (CEMs) for NO_x, SO_2, and O_2

For the duration of the project, a CEM will be installed and operated by SaskPower personnel at the inlet to the slip stream SCR reactor to facilitate the evaluation of inlet flue gas quality. A second CEM, previously used for testing at the Emissions Control Research Facility, will be installed at the outlet of the SCR to quantify the impact of the SCR on NO_x, SO_2, and O_2 in the flue gas. Additionally, both CEMs will be capable of monitoring carbon monoxide (CO) and carbon dioxide (CO_2). Data from both CEMs will be transferred to the ECRF data logging system.

Measurement of Ammonia and Sulphur Trioxide

Ammonia (NH_3) slip and sulphur trioxide (SO_3) after the catalyst will be measured periodically with recognized extraction methods. The use of on-line equipment is being

investigated and if suitable instrumentation is identified, consideration will be given to installing it.

Field Mounted Process Measurement Elements

B&W will provide field-mounted process measurement elements to enable regular recording and logging of pressure drop across the catalyst layers, inlet gas temperature to the reactor, and gas flow measurement through the reactor.

Plant Data

SaskPower plant data is recorded by an OSI PI enterprise system. Appropriate plant data from this system will be available to the project test team for analysis.

Catalyst Analysis

Removed catalyst layers will be sent to a laboratory for analysis, which will include visual inspection and/or chemical analysis of deposits. Depending on the results of testing, removed catalysts may be tested to determine the characteristics of the ash adhered to the catalyst surface and in the catalyst pores, similar to the testing completed in previous field slipstream testing of SCR catalysts (1).

DELIVERABLES

Project deliverables will include regular updates of progress to key team members including NDIC, B&W and SaskPower. Regular reports will be submitted as required by NDIC.

At the conclusion of the tests, a draft report, including recommendations for catalyst application to lignite coal, will be submitted to NDIC for comment and review. After the receipt of these comments, a final report will be submitted to all project participants. Specific reporting requirements of the NDIC will also be addressed.

STANDARDS OF SUCCESS

The successful outcome of this project will identify and detail long-term operating concerns and recommendations for catalyst application to lignite coal-fired boilers, allowing utilities to assess the technology with less uncertainty if future environmental regulations require NO_x reduction. This project will be one of the first to assess long-term viability of SCR technology for NO_x reduction in a lignite-fired power plant. Operating issues, including preferred temperatures, pressure drops, and catalyst life, will be assessed.

The proposed team of SaskPower, B&W and NDIC has a demonstrated successful track record of completing projects related to controlling emissions from lignite-fired power plants. A similar successful outcome is anticipated in this project.

BACKGROUND

NO_X control is achieved through combustion control or post-combustion control. It is anticipated that combustion control by itself will not be sufficient to meet NO_X reduction requirements in the future. SCR technology is a form of post-combustion NO_X control that has been widely employed by coal-fired utilities. SCR reactors employ a metal-based catalyst to accelerate the reduction reaction of NO_X into nitrogen and water vapour. The SCR process has been widely employed across North America for non-lignite combustion flue gas. Very limited testing of the technology has been conducted on lignite flue gases, including Fort Union lignite flue gases.

The US EPA calls for application of BACT under the New Source Performance Standards and BART for stationary combustion units of a certain age. Generally, the BACT and BART for NO_x control is SCR. Other regulatory drivers that could result in

utilities installing SCR on their units include efforts to reduce regional haze and progressively more strict limits on ambient levels of fine particulates and ozone.

In the limited slip stream testing of SCR on coal-fired boilers burning Fort Union lignite fuels that has occurred to date, potential operating concerns have been identified resulting in problems for utilities in North Dakota. Similarly, SaskPower is facing challenges in planning for anticipated Canadian Clean Air Rules that will require NO_x reductions, which cannot be achieved through currently available combustion controls alone. North American utilities must be prepared for a future in which emissions regulations require substantial reductions in NO_x, which means addressing potential operating concerns with SCR in a timely manner.

In its 2008 technical feasibility analysis of SCR for North Dakota lignite, the North Dakota Department of Health (NDDH) concluded that pilot scale testing would be required to address unresolved problems with adapting SCR technology to a unit firing North Dakota lignite. Some of the main problems identified by NDDH and others included more severe plugging and catalyst deactivation than units firing other fuels, shorter catalyst operating life, a definitive difference between flue gas generated at units firing North Dakota lignites than units burning other types of coal, and stickier, potentially more abrasive ashes.

One of the key studies referenced in the NDDH report was conducted by the Energy & Environmental Research Center (EERC) at the University of North Dakota. In the EERC project, tests were performed using a portable slipstream SCR unit (with ammonia injection capability) at a lignite-fired cyclone boiler unit – Otter Tail Power Company's Coyote Station (near Beulah, North Dakota) - and at two utilities firing subbituminous

coal (1). Approximately 400 acfm of flue gas was extracted from the convective pass of the boiler using an induced-draft fan. During the test program, parameters such as catalyst temperature, pressure drop, and flue gas temperature, composition, and velocity were regularly monitored and recorded. Catalyst samples were removed and analyzed for reactivity-reducing compounds after two, four, and six months (1).

Significant plugging of the Haldor Topsoe catalyst was experienced at Coyote Station after only 750 hours in operation and attempts to remove the deposits with aggressive air pulsing were unsuccessful (1). Greater pressure drop across the catalyst and visible plugging were observed at Coyote Station than at the subbituminous-fired units using the same catalyst and SCR (1). Deposits on samples removed at two and four month intervals were characterized as fly ash bonded by a matrix "likely in the form of calcium sulphate" (1). The catalyst layers at Coyote Station were plugged and the pores deactivated after a much shorter operating life than the typical 10,000 to 30,000 hours (2).

Based on the EERC's findings and those of others, NDDH deemed that "to design and install an SCR system for a unit firing North Dakota lignite without obtaining additional data from bench scale or pilot scale testing would be experimentation" (2). Extensive pilot scale testing will be required to answer the questions surrounding future application of SCR to lignite-burning units.

QUALIFICATIONS

The project team members have considerable experience with pollution abatement technologies. In addition, team members have worked together in the past on a number of collaborative projects with successful outcomes.

SaskPower Experience

SaskPower has considerable experience in participating in various field test programs conducted at its plants.

SaskPower has been involved in numerous projects testing various forms of sorbent injection for SO_2 control. This approach for managing SO_2 emissions was thought to be suitable for Fort Union lignites because of their low sulphur levels and the potential of this SO_2-control strategy to avoid the installation of expensive SO_2-scrubbing vessels. The sorbent injection test projects evolved from feeding limestone into the coal feed, through injecting limestone or hydrated lime into the furnace exit and injecting hydrated lime into the economizer outlet. Ultimately, a full-scale demonstration of LIFAC technology (where injected limestone into the furnace exit is reactivated in a humidification chamber between the air heater and the particulate control device) was conducted at Poplar River Power Station that led to the commercial installation of this technology at SaskPower's Shand Power Station.

The most serious emissions control issue to SaskPower is the need to find a viable way to mitigate its CO_2 emissions. SaskPower has a long history of addressing CO_2 emissions with the construction of a slipstream CO_2-control plant at its Boundary Dam Power Station in the 1980s. This slipstream plant has had several upgrades over the years and SaskPower is now working with the University of Regina's International Test Centre to continue its operation to further the development of CO_2-control technologies. SaskPower has also been heavily involved with the Weyburn CO_2 injection project to ensure that CO_2 injected there for enhanced oil recovery is safely sequestered for the long

term. SaskPower is also a founding member of the Canadian Clean Power Coalition and has been actively engaged in all their CO_2-control projects.

Most recently SaskPower has been involved with numerous mercury control projects. This includes co-sponsoring various NDIC-supported projects hosted by North Dakota utilities or led by North Dakota researchers. SaskPower has conducted extensive mercury control work at the ECRF that has gained widespread attention and support, including key funding from NDIC. The mercury-control work at the ECRF has helped SaskPower determine how to achieve mercury control at its plants and a full-scale permanent carbon injection system is currently under construction at Poplar River.

SaskPower has conducted several NO_X-control projects, including the installation of the first low NO_X combustion system in Canada, operating adjustments to reduce NO_X and early tests of selective non-catalytic reduction by injecting a solution of urea into Poplar River Unit 1. These various tests and advice from NO_X-control technology suppliers have led SaskPower to conclude that these methods alone will not meet its future NO_X emissions reduction requirements. Therefore, demonstrating the effectiveness of SCR on Fort Union lignite flue gases is required.

SaskPower Project Management

Dr. David Smith is the Project Leader of Environmental Initiatives, Operations Support, with SaskPower. He leads a team of research engineers and operators to conduct several projects related to emission control and coal utilization by-product management issues. In a larger sense, he is a key liaison between SaskPower, several industrial and governmental organizations, operations, and researchers. He has worked closely with federal, provincial, and other government leaders to perform research related

to air emissions control to meet current and future emission regulations and standards. He oversaw the development and construction of the Emissions Control Research Facility at Poplar River Power Plant in 2004. He will play a key role in coordinating the SaskPower effort that will be committed to this proposed work.

Mr. Conway Nelson is a Senior Mechanical Engineer with 10 years of project management experience. Prior to joining SaskPower, he worked for an engineering consulting company on petroleum projects. During his time at SaskPower , he has managed numerous capital upgrade projects for thermal and hydro power stations, including additions to the Emissions Control Research Facility at the Poplar River Power Station. His most recent project was the refurbishment of a 300 MW coal fired boiler at the Poplar River Power Station. Mr. Nelson currently supervises the Mechanical Engineering group that will be responsible for installing the slipstream SCR unit and other equipment required for this project.

Babcock & Wilcox Experience

Babcock & Wilcox brings over 140 years of experience designing, manufacturing, erecting, and commissioning power generation systems. Over the past forty years, B&W has expanded its array of product offerings to include first combustion-related emissions reduction equipment and then post-combustion emissions control systems. Drawing on lessons learned over four decades, B&W has designed and installed emissions control systems ensuring successful outcomes.

B&W's leadership in the field of NO_X reduction technology began in 1962 with the first patented overfire air port system design for reducing NO_X emissions. That leadership continues with unparalleled experience, proven equipment, and innovative technology for

NO_X reduction solutions. B&W's systems are designed to be cost-effective, dependable, and adaptable to the full range of fuels and boiler arrangements in new or retrofit applications. B&W entered into a licensing arrangement for the design and supply of Selective Catalytic Reduction systems in 1982. Since that time, the company has expanded its product offerings, working with a host of suppliers worldwide to retrofit over 26,000 MW of power generation capacity (design and erection) with these post-combustion NO_X control systems as well as providing SCRs as part of the boiler OEM supply on many units. Considering units supplied plus other SCR that B&W has erected, B&W has been engaged in over 46,000 MW of SCR projects in North America or approximately 30% of the total market.

B&W has extensive experience delivering post-combustion NO_X control systems, both stand-alone and in combination with combustion modifications. Further, B&W's technical expertise in boiler design enhances our ability to provide the required design integration of the SCR with the boiler considering such factors as economizer outlet temperature, flue gas flow distribution, and boiler implosion potential (related to increased system pressure drop).

Challenging performance guarantees have routinely been met or exceeded with B&W's SCR systems. Guarantees have ranged from 50 to 90+% NO_X removal levels with ammonia slip levels typical of industry standards. B&W-designed SCR systems have not only met customer-required reduction levels during post-erection performance testing but also over the long run. Further, B&W's in-depth knowledge of boiler systems, our attention to detail, and our technical focus on such key components as

customized mixing and distribution devices have enabled customers to achieve this long term performance with minimal operating and maintenance expense.

Previous B&W Slipstream SCR Test Experience:

In collaboration with a US utility and a catalyst supplier, B&W was the lead on a slip stream reactor study which evaluated the effects of PRB ash on catalyst. This study included two parallel slip streams, each 1000 ACFM flow rate, on an operating unit to evaluate different types of catalyst and different cleaning methods. This slip stream reactor testing was conducted over a 10,000 hour operating period. Results were helpful for all three parties in demonstrated performance and design application.

Roles of Project Leads for Babcock & Wilcox:

Donald Tonn, Technical Consultant, Air Quality Control System Technology, B&W US;

- Technical direction of the overall project
- Coordination of all activities with the catalyst supplier
- Design oversight of the slip stream reactor components
- Responsibility for catalyst arrangement to suit the need for initial and replacement modules throughout the test period with the flexibility for field testing and laboratory tests.

Malcolm Mackenzie, Senior Project Engineer, B&W Canada;

- B&W's project coordinator
- Develop arrangement drawing
- Prepare P&I D
- Coordinate fabrication of slipstream reactor
- Develop test plan

VALUE TO NORTH DAKOTA

In expectation of future environmental regulations requiring further reductions in NO_x emissions, North Dakota utilities may be interested in SCR technology, which has been widely employed across North America in non-lignite coal-fired boiler applications. Limited slip stream tests have identified potential operating concerns (e.g., catalyst fouling) with SCRs where Fort Union lignite is fired; however, no long-term assessments have been carried out.

As confirmed by NDDH in its Technical Feasibility Assessment of SCR, it is economically critical that potential concerns be identified and addressed in advance, before SCR technology is installed full scale in a lignite-fired boiler application. The proposed project would provide valuable data on the long-term viability of SCR reactors where Fort Union lignite is fired. Poplar River burns a Fort Union lignite coal, meaning results will be applicable to coals burned in North Dakota plants.

MANAGEMENT – ROLES OF PROJECT PARTICIPANTS

The proposed team for this project includes SaskPower, which will serve as the site host at its Poplar River Power Station Unit 1, B&W Canada Ltd. and NDIC.

SaskPower

SaskPower agrees to serve as the host site for this project and provide program project management. SaskPower will fabricate and supply inlet and outlet gas ducts, equipment supports and fastener hardware, required fans and/or blowers, gas analyzers, a data acquisition system, controls and electrical equipment, instrument air, field labour and technical advice for installation of the slip stream SCR system. SaskPower's ECRF test crew will be available for the duration of testing, operational monitoring and periodic

performance testing. SaskPower will also be responsible for removing the system at completion of the test program.

Babcock & Wilcox

B&W agrees to provide technical coordination of the project program and a detailed test plan. B&W will design and supply the slip stream SCR reactor, including casing, arrangement of inlet and outlet ducts and various mechanical equipment, gas mixing and distribution devices, and an ammonia injection grid. A technical advisor will be provided for system checkout and placing the SCR reactor in service. The catalyst program will be managed by B&W, including interfacing with suppliers, supply of test samples (assuming donated), and periodic inspection and testing at 4000 operating hour intervals. Upon completion of the program, B&W will prepare a report, including recommendations for catalyst applications to lignite coal.

NDIC

NDIC will assign a performance monitor who will be involved in the discussions and plans related to this project, as well as ongoing evaluation of the test results. This involvement will include finalizing details for the test plan, participation in regular conference calls to update the team on project progress, and receiving and reviewing regular reports. It is possible that the NDIC representative may choose to conduct a site visit to Poplar River Power Station during the course of testing. SaskPower agrees to accommodate them as part of the team, with written prior notice.

A more detailed outline of the roles of SaskPower and B&W is shown in Table 2.

Table 2. Scope of SaskPower's and B&W's Contributions to the Proposed Project

1. SaskPower's Scope:

- Program project management
- Fabrication and supply of
  - inlet and outlet gas ducts c/w isolation valves, flow control valve(s) expansion joints and gaskets
  - equipment supports incl. support steel, hangers etc.
- Supply of catalyst test samples if not donated by catalyst supplier(s) to the test program
- Catalyst testing at intervals of approximately 4,000, 8,000, 12,000 and 16,000 operating hours if this service is not donated by the catalyst supplier(s) to the test program.
- Fan / blower if required
- Anchor bolts, and all fastener hardware
- Transmitters, if required by test plan, for sensing elements supplied by B&W
- Gas analyzers / monitors and balance of instrumentation not supplied by B&W
- Data acquisition system
- Controls and electrical equipment
- Electrical power
- Instrument air for instruments and "on-line" cleaning of catalyst
- Field labour
- Field installation of entire system
- Technical advisor (if required) for field installation
- Operation and maintenance of SCR slip stream system
- Consumables (ex. ammonia) if required
- Regulator for anhydrous ammonia if tests include ammonia injection
- System operational monitoring including
  - DCS or other indication data
  - Concentrations of NO_X, SO_2 and O_2 at reactor inlet
  - Gas temperature
  - Unit load
- Periodic performance testing if required in detailed test plan
- Removal of system from location after program completion
- Preparation for shipment and loading of B&W supplied equipment for shipment to B&W
- Disposal of any B&W supplied equipment that B&W elects not to have returned to B&W

2. B&W's Scope:

In general, B&W will fund;

A) A technical services role in developing a recommended program, providing technical oversight, design engineering of the mechanical components and evaluation of test data.

B) Supply of reactor components and certain instrumentation as defined.

B&W's scope would include:

- Overall technical coordination of program
- Detailed test plan
- Design of reactor plus arrangement of inlet and outlet ducts and miscellaneous mechanical equipment
- Reactor including;
  - Casing
  - Inlet and outlet transitions
  - Gas mixing and distribution devices
  - Ammonia injection grid (if required)
- Field mounted process measurement elements on slip stream for
  - Pressure drop across catalyst
  - Inlet gas temperature to reactor
  - Gas flow measurement through reactor
- Specification of instrumentation to be provided by SaskPower
- Interface with catalyst suppliers and manage catalyst program
- Manage supply of catalyst test samples assuming that catalyst suppliers donate these to the test program
- Manage catalyst testing at intervals of approximately 4,000, 8,000, 12,000 and 16,000 operating hours assuming that catalyst suppliers donate this service to the test program
- Shipment of BWC supplied equipment to and from test site
- Technical advisor for:
  - System checkout
  - Placing slip stream SCR in service
- Periodic inspection at 4,000, 8,000, 12,000 and 16,000 operating hours
- Replacement catalyst samples (if donated by catalyst supplier)
- Slip stream program report
- Recommendations for catalyst application to lignite coal
- Travel, local living and transportation expenses for services provided by B&W's personnel in B&W's scope

TIMETABLE

The project is proposed for a 33 month period, including approximately 7 months of lead time from the agreement to proceed to the reactor being placed in service, 24 months in operation, and 2 months for evaluation of results and preparation of the final report. Table 2 shows the projected schedule of activities that will be performed under the proposed project.

Table 3. Proposed Project Time Line

Project Activity	Period of Activity
Finalize locations for reactor and flue connections	September 2008
Design, fabricate, install, and place in service	September 2008–December 2008
Remove 1st catalyst block after 4000 operating hours	June 2009
Remove 2nd catalyst block after 8000 operating hours	December 2009
Remove 3rd catalyst block after 12000 operating hours	June 2010
Remove 4th catalyst block after 16000 operating hours	December 2010
Evaluation of results and final report	January-February 2011

BUDGET & MATCHING FUNDS

The total cost of completing this project is estimated at approximately $1,050,000, most of which is not addressed in this request. The bulk of the funding is associated with acting as host facility, designing, fabricating, and installing the slip stream reactor, and providing support staff for the research project. SaskPower's contribution is estimated to be $700,000 while Babcock & Wilcox Canada Ltd.'s contribution is estimated to be $150,000. SaskPower requests that NDIC provide $200,000 toward the proposed work.

A breakdown of the proposed project costs is presented in Table 4.

Table 4. Funding Outline for Slipstream SCR Demonstration

	B&W	SaskPower	NDIC	Total
Slipstream SCR Reactor Supply				
Engineering	$90,000			$90,000
Materials & Expenses	$60,000			$60,000
	$150,000			$150,000
SCR Reactor Installation				
Access paltforms		$40,000		$40,000
Reactor tie-in into the unit		$100,000		$100,000
Electrical costs		$30,000		$30,000
Instrumentation & Controls		$10,000		$10,000
Construction		$10,000		$10,000
Engineering		$20,000		$20,000
Consultants		$15,000		$15,000
Other costs		$75,000		$75,000
		$300,000		$300,000
Monitoring Equipment				
Monitoring System		$140,000		$140,000
Equipment Installation		$60,000		$60,000
		$200,000		$200,000
Testing				
Engineering Support		$12,500	$12,500	$25,000
Test Crew		$137,500	$137,500	$275,000
Maintenance		$50,000	$50,000	$100,000
		$200,000	$200,000	$400,000
Project Total	$150,000	$700,000	$200,000	$1,050,000

Note: Funding for this project will come from a combination of Canadian and U.S. sources. Parity is assumed for the two currencies in these cost estimates

NDIC funding is being requested to ensure that the project can run for the entire proposed 33 month project duration including 16,000 operating hours or about two years of actual test work. Resources from the requested funding will also be used to communicate to NDIC the results of this test work in a timely fashion and to deal with any more detailed information requests that may come from North Dakota utilities.

TAX LIABILITY

SaskPower – a Crown corporation in the Province of Saskatchewan – does not have an outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

CONFIDENTIAL MATTER

There is no confidential matter contained in this proposal. In the course of testing various catalysts, confidential information may be discussed and information shared between SaskPower and B&W. In addition, certain matters pertaining to SaskPower's and B&W's business practices and other information will be kept confidential, as outlined in a separate confidentiality agreement between SaskPower and Babcock & Wilcox Canada Ltd. effective January 22, 2008. It is understood that NDIC will expect data related to the project, as well as contextual operational and plant information, which will be provided and made public with the report.

Over the course of this project new intellectual property may be produced that will belong to B&W. Although this information will not be disclosed in the program report, this information can be made available to North Dakota utilities considering installing SCR technology upon reaching a confidentiality agreement with B&W.

REFERENCES

1. Benson, S.A.; Laumb, J.D.; Crocker, C.R.; Pavlish, J.H. *SCR Catalyst Performance in Flue Gases Derived from Subbituminous and Lignite Coals*. Fuel Process. Technol. 2005, 86 (5), 577–613.

2. Division of Air Quality, ND Department of Health, Bismarck, ND. *Best Available Retrofit Technology – Selective Catalytic Reduction Technical Feasibility Analysis for North Dakota Lignite*; March 2008.

APPENDIX A

RESUMES OF KEY PERSONNEL

David W. Smith, Ph.D.

Project Leader, Environmental Initiatives
Operations Support
Saskatchewan Power Corporation
2025 Victoria Avenue
Regina, Sask. S4P 0S1
Tel.: (306) 566-2290 Fax: (306) 566-3348
e-mail: dsmith@saskpower.com

CURRENT RESPONSIBILITIES:

- Direct test programs at SaskPower's Emissions Control Research Facility;
- Determine appropriate projects to properly position SaskPower for dealing with anticipated emissions restrictions;
- Represent SaskPower in multi-stakeholder and other processes for various regulatory emissions reductions initiatives;
- Act as Power Production's lead technical representative in SaskPower's Partnership process with Saskatchewan Ministry of Environment;
- Provide expert advice for corporate environmental policy and response to queries;
- Assess options for improving SaskPower's existing emissions controls;
- Recommend unit efficiency improvements with the least adverse environmental impact, such as burner balancing and reduction of excess air without generating toxic emissions;
- Determine stack emissions from thermal units and recommend ways to reduce emissions at least cost with minimum adverse impact on operating practices through adjustments in operating conditions and equipment;
- Support Engineering Services and the power plants with emission control projects by providing testing support and expert advice;
- Maintain central environmental stack gas emission and water quality databases;
- Support plant reporting and other environmental activities;
- Supervise Environmental Initiatives staff and manage the group's budget.

CURRENT ACTIVITIES:

- Direction of current mercury control project at SaskPower's ECRF;
- Management of SaskPower's other mercury research and monitoring activities;
- Determination and implementation of new test activities at the ECRF to deal with upcoming reduction requirements for various emissions;
- Evaluation of commercial emissions control technologies for meeting SaskPower's anticipated regulatory requirements;
- Exploration of opportunities to reduce emissions through coal quality improvements;
- Negotiation of key environmental initiatives to be undertaken by SaskPower through Environmental Partnership Agreement with Saskatchewan Ministry of Environment;
- Participation in the activities of the South East Saskatchewan Airshed Association;
- Activity in plant projects aimed at reducing emissions.

PREVIOUS ACCOMPLISHMENTS:

- Power Production representative on Environmental Partnership negotiations;
- Coordination of Power Production efforts leading to ISO 14000 registration.
- SaskPower representative on on various stakeholder consultation groups dealing with environmental regulatory initiatives resulting emissions reductions requirements;
- SaskPower representative on bilateral Souris Basin Air Quality Issues working group;
- SaskPower liaison with CEA committees dealing with federal initiatives such as Canada-Wide Standards for fine particulates and ozone, changes to requirements of the National Pollutant Release Inventory and development of an integrated air emissions strategy;
- SaskPower representative on CEA Flue Gas Emissions Control Advisory Panel.
- Nitrogen oxides (NO_x) emissions reduction by combustion modification activities;
  - Completed a detailed survey of NO_x emissions at SaskPower's thermal plants,
  - Optimized plant operating conditions with respect to NO_x, demonstrating NO_x emissions reductions of up to 40% at negligible cost, leading to the avoidance of annual costs of millions from using chemically-based NO_x control methods,
  - Identified opportunities to increase unit efficiency and decrease plant operating costs operating condition adjustments,
  - Achieved favourabe modification of proposed NO_x emissions guidelines.
- Demonstration of urea injection for controlling nitrogen oxides;
- Carbon Dioxide (CO_2) Injection at Boundary Dam;
  - Recommended injection of CO_2 into the cooling water at Boundary Dam for scale control, implementation of which has been estimated to result in annual cost reductions exceeding $1,000,000 were estimated by Boundary Dam under highly scaling conditions.
- Support of LIFAC Sulphur Dioxide Control Projects at Poplar River and Shand.
- Fouling and Slagging Alleviation;
  - Prediction and control of slagging and fouling problems by altering ash chemistry,
  - More recent involvement in power plant slagging problems has included study of operating parameters such as combustion conditions and coal-milling practices.
- Management of Shand Ash;
  - A process was developed to manage a unique combustion by-product, meeting new and more strict environmental regulations,
  - Suitability of this ash for new markets identified.

PROFESSIONAL MEMBERSHIPS:

- Chemical Institute of Canada;
- American Chemical Society;
- Air and Waste Management Association, Canadian Prairie and Northern Section.

EDUCATION:

- Ph.D. (Chemistry), the University of British Columbia, Vancouver, B.C;
- B.Sc. (Chemistry), Carleton University, Ottawa, Ontario.

Resume′ of
CONWAY NELSON, P. Eng.

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Regina, Sask.
S4S-3H7
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work: (306) 566-2967
e-mail: clnelson@saskpower.com

ENGINEERING WORK EXPERIENCE

August 1, 2008 to present

Senior Mechanical Engineer
SaskPower Corporation
Supervisor: John Lebersback, P. Eng.

- Responsible for supervision of the Mechanical Engineering department in the Engineering Services group.
- Assign projects to six directs reports, review and approve cost estimates, draweings, specifications, requests for proposals, schedules, purchasing recommendations and assist with technical or commercial issues on various capital projects.
- Responsible for major technology recommendations to comply with new emissions regulations, including working with internal and external research teams to evaluate various technologies from a technical and economic perspective.

March 1, 2006 to July 31, 2008

Project Leader
SaskPower Corporation
Supervisor: John Lebersback, P. Eng.

- Responsible for all aspects of project management for large, multi-year projects including; scheduling, cost estimating and cost control, preparation of tender and request for proposal documents, evaluation of tenders and proposals, negotiating and administering contracts with suppliers, contractors and consultants.
- Managed a project to refurbish a 300 MW Boiler at the Poplar River Power Station.
- Responsible for major technology recommendations to comply with new regulations, including working with internal and external research teams to evaluate various technologies from a technical and economic perspective.

ENGINEERING WORK EXPERIENCE (cont.)

April 1, 2003 to March 1, 2006

Mechanical Engineer II
SaskPower Corporation
Supervisor: Ron Bend, P. Eng.

- Similar to current position, progressed through projects of increasing complexity and size in during my time in this position.
- Established and administered various supply, labour, and engineering consultant contracts for various projects.
- Worked with different departments within the company on a daily basis (plant staff, drafting, project services, purchasing, legal, insurance) to ensure that projects ran smoothly and were completed on time and on budget.
- Worked with an interdisciplinary team on projects, typically in a lead role, where I was responsible to monitor progress and ensure tasks were completed as scheduled in order to meet plant shutdowns.

March 13, 2000 to April 1, 2003

Mechanical Engineer I
SaskPower Corporation
Supervisor: Dwight Blair, P. Eng.

- Similar to the Engineer II role, worked on smaller, lower priority projects.

March 19, 2001 to May 30, 2001

Construction Engineer
SaskPower Corporation
Supervisor: Bob Turczyn, P. Eng.

- Assisted in all aspects of Construction Supervision for the PR1 Downpass Upgrade contract.
- Worked closely with the contractor and plant personnel to ensure that all work was done safely, and to ensure that simultaneous work was properly co-ordinated.
- Reviewed work of contract and addressed quality concerns as required.
- Reviewed the contractor's Quality Control package.
- Worked with plant personnel to prepare for boiler hydrotest.

Jan. 19, 1998 to March 10, 2000

Junior Project Engineer
BAR Engineering Ltd.
Supervisor: Neil Noble, P. Eng.

- Performed various calculations relating to fluid flow, heat transfer and equipment sizing.
- Prepared designs for capital upgrades to Oil and Gas facilities.
- Responsible for preparing project Design Basis Memorandums, Cost Estimates and schedules.
- Dealt with suppliers and contractors on a daily basis to discuss the schedule and progress of various construction projects.

- Maintained close contact with construction supervisors over the course of a project to ensure that the project schedule and applicable design requirements were met.
- Responsible for project cost control.

EDUCATION

November 15, 1999 to Nov. 19, 1999	COADE Engineering Software Calgary, Alberta **CAESAR II Pipe Stress Analysis Seminar**
September 3, 1993 to Dec 31, 1997	University of Saskatchewan Saskatoon, Sask. **College of Engineering** **Obtained B. Sc. in Mechanical Engineering**

COMPUTER SKILLS

- Extensive knowledge of Windows O/S, Microsoft Word, Microsoft Excel, Microsoft Project, Lotus Notes.
- Extensive knowledge of AutoCAD, including 3D modeling of solids.
- Extensive knowledge of CAESAR II Pipe Stress Analysis Software

PROFESSIONAL AFFILIATIONS

- Registered as a Professional Engineer with the Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS).
- Currently working towards a Project Management Professional Designation (exam December 2008).

ACTIVITIES & INTERESTS

- I enjoy training for and competing in triathlon and running races.
- Completed the Queen City Marathon in 2002 and from 2005 to 2008 as well as the Manitoba Marathon in 2003.
- Completed the Ironman Canada Triathlon in 2005 and 2007.
- Member of the Saskatchewan Provincial Triathlon team from 2006 to 2008.

RESUME

Donald P. Tonn, Technical Consultant
AQCS Technology
Process Technology
The Babcock & Wilcox Company
Power Generation Group
Barberton, Ohio

EDUCATION

B. S. - Mechanical Engineering, Kansas State University, 1969.

PROFESSIONAL EXPERIENCE

1969 to Present **The Babcock & Wilcox Company - Barberton**

2005 to 2008 **AQCS Technology**
Technical Consultant

Responsible for functional/process technology of the SCR DeNOx systems and both wet and dry precipitator systems. This includes serving as product technical representative in specific technology areas for both NOx reduction and particulate control.

2000 to 2005 **Environmental Technology**
Senior Advisory Engineer – Barberton, Ohio

Responsible for functional/process technology of the SCR DeNOx systems and both wet and dry precipitator systems. This includes serving as product technical representative in specific technology areas for both NOx reduction and particulate control.

1996 to 2000 **Process/Project Engineering**
Senior Advisory Engineer – Barberton, Ohio

Responsible for performance and process technology of the SCR DeNOx systems. This includes serving in an advisory/consulting capacity for the application of the technology on both proposal and contract projects.

1990 to 1996 **Process Engineering**
Advisory Engineer - Barberton, Ohio

Responsible for functional/process technology of the SCR DeNOx systems. Also serving as Group Leader supervising the process engineers on all SCR proposal and contract projects. Responsible for precipitator performance technology.

1989 to 1990 **Environmental Systems Engineering**
Advisory Engineer - Barberton, Ohio

Responsible for maintaining precipitator functional technology, for developing and maintaining baghouse technology and for developing function technology on other environmental equipment. As part of Contract Engineering section, also responsible to serve as lead engineer for proposals and contracts on environmental systems projects.

1987 to 1989 **Industrial Performance Engineering**
Advisory Engineer - Barberton, Ohio

Responsible for maintaining precipitator functional technology and for developing functional technology on other environmental equipment. Also responsible for the execution of boiler contract performance checks and calculations.

1984 to 1987 **Environmental Systems Functional Engineering**
Principal Engineer - Barberton, Ohio

Responsible for maintaining precipitator functional technology and providing support in market efforts.

1974 to 1984 **Environmental Control Systems Engineering**
Functional Engineer - Barberton, Ohio

Responsible for functional sizing of precipitators and providing technical assistance in proposal preparation on new and retrofit applications.

1969 to 1974 **Kansas City District and Cleveland District Service Engineer**

Responsible for checkout, start-up and maintenance of fossil fired boilers and accessory equipment for both utility and industrial applications.

1969 **Joined Babcock & Wilcox as a Graduate Engineer**

TECHNICAL PUBLICATIONS

- D.P. Ritzenthaler - AEP, J.D. Hume – AEP, A.L. Moretti, D.P. Tonn – Evolution of AEP's SO3 Mitigation System. Presented to Air Quality VI, Arlington, Virginia, September 24 – 27, 2007

- S.A. Bjorklun – Burns & McDonnell; G. Burnett – Kansas City Power & Light; D.P. Tonn, K.E. Redinger – The Status of Advanced Emission Control Systems Installed on Hawthorn Unit 5. Presented to PowerGen International, Orlando, Florida, November 30 – December 2, 2004.

- D.P. Tonn, K.R. Robison – AES Somerset LLC, Somerset SCR Experience after Three Operating Ozone Seasons. Presented at DOE, NETL 2002 Conference on SCR and SNCR for NOx Control, May 15 -16, 2002.

- G. Burnett – KCP&L, D.P. Tonn, K.E. Redinger, R.E. Snyder, M.G. Varner, Integrated Environmental Control on the 21st Century's First New Coal-Fired Boiler. Presentated at EPA,DOE,EPRI Mega Symposium, Chicago, Illinois, August 20-23, 2001.

- W. Becker, D. Tonn, B&W; N. Stephenson, Cormetech; K. Speer, Duke Energy; B&W's NOx Reduction Systems and Equipment at Moss Landing Power Plant. Presented at ICAC NOx Forum, Washington D.C. March 23-24, 2000.

- A.D. LaRue, E.M. Schulz, D.P. Tonn, 4 X 550 MWe Boiler Operating Experience at 0.15lb/10^6 BTU NOx Emission Level Firing a Broad Range of Coals. Presented at EPRI- DOE-EPA "MEGA Symposium" Atlanta, Georgia, August 16 – 20, 1999.

- D.P. Tonn, T.A. Uysal, 2200 MW SCR Installation on New Coal-Fired Project. Presented at American Power Conference, Chicago, Illinois, April 14 – 16, 1998.

- D. Zamorano, Southern California Edison; D.P. Tonn, J.M. Wilkinson, B&W, Case Study in the Retrofit of Selective Catalytic Reduction (SCR) Technologies in the U.S. Presented at ICAC Forum 1994, Arlington, Virginia, November 1 – 2, 1994.

- H. J. Heer, N. Seyfert, D. P. Tonn, R. W. Kronenberger, Experience with Electrostatic Precipitators Downstream of Spray Absorbers for SO_2-separation. Presented at 10th Particulate Control Symposium and 5th Conference on Electrostatic Precipitator, Washington D.C., April 5-8, 1993.

- D. P. Tonn, R. W. Kronenberger. Meeting Particulate Emissions Regulations on Low Sulfur Coal-Fired Units with Electrostatic Precipitators. Presented to IGCI Forum 91, Washington D.C., September 11-13, 1991.

- J. M. Wilkinson, D. P. Tonn. Baghouse vs. Precipitator for Dry Scrubber Systems Pilot Study Results. Presented to Coal Technology Conference, Houston, Texas, November 17-19, 1981.

PATENTS

No. 5,618,499. E.C. Lewis, D.P. Tonn, M.G. Varner. Catalyst Outage Protection System. Issued April 8, 1997.

No. 5,525,317. P.A. Bhat, D.P. Tonn. Ammonia Reagent Application for NOx, SOx, and Particulate Emission Control. Issued June 11, 1996.

No. 5,215,557. D. W. Johnson, R. B. Myers, D. P. Tonn. Dry scrubber with Integral Particulate Collection Device. Issued June 1, 1993.

No. 5,250,267. D. W. Johnson, R. B. Myers, D. P. Tonn. Particulate Collection Device with Integral Wet Scrubber. Issued October 5, 1993.

RECENT ACTIVITIES

Have actively served as advisor/consultant for all of the B&W SCR projects, both proposals and contracts, since the early 1990's. Specific areas of expertise have included SCR application and performance; project guarantees; catalyst performance and selection; gas flow modeling; process design of ammonia handling, storage, vaporization, mixing, and injection; and performance testing. These SCR activities have also included technology discussions and exchange with catalyst suppliers and with technology licensor. In addition responsibilities have included input and development of the B&W SCR R&D programs as well as documenting the experiences, guidelines, and standards for the product technology.

C. Malcolm MacKenzie
Experience Profile

EDUCATION

B.A.Sc., Mechanical Engineering, University of Toronto, Ontario, Canada, 1981

PROFESSIONAL ASSOCIATIONS

Professional Engineers Ontario
Ontario Society of Professional Engineers

CAREER HISTORY

Current Position — **Senior Project Engineer, Environmental Products**
Babcock & Wilcox Canada, Cambridge, Ontario

Lead Engineer on the integration of Environmental equipment into Company Product Line.

- Reviewing available technologies
- Coordinating technology transfer
- Developing Standard Design Procedures

Oct 2003 – Dec 2006 — **Project Manager, Nuclear Services**
Babcock & Wilcox Canada, Cambridge, Ontario

Project Manager for Advanced Feeder Tooling development Contract

- Acted as Overall Project Manager for AECL/BWC Team
- Joint Customer Bruce Power / Ontario Power Generation
- Successfully developed complete toolset to perform remote, feeder pipe repairs
- Tools first used at Darlington Nov/Dec 2006

April 2003 – Oct 2003 — **Program Manager, B&W Integran**
Babcock & Wilcox Canada, Cambridge, Ontario

Responsible for all aspects of Business Unit Performance including:

- Financial Performance including equity income associated with the Integran Joint Venture
- Product Development (Please refer below)
- Sales/Marketing support for Integran
- Contract Execution

2000 – April 2003 **Project Manager, B&W-Integran**
Babcock & Wilcox Canada, Cambridge, Ontario

Responsible to coordinate product development from fundamental R&D through introduction to B&W product lines. Key successes to date include:

- Development of GBEST process leading to the installation of airport openings in two recovery boilers
- Development of co-deposited SiC and B4C wear alloys. Trial installation at Howe Sound
- On-going development of CANDU feeder repair

Presented papers at several industry meetings to promote the Integran Technologies (CNS CANDU Repair, ICRC, CPPA, CBS)

Nuclear related research included:

- Development of GBE process for Alloy 690 steam generator tubes boilers
- In situ CANDU feeder repair
- PWR reactor head nanoplating of control rod penetrations

1997 - 2000 **Project Manager/Industrial Specialist**
RWDI, Guelph, Ontario

Introduced new engineering and service products including boiler airflow optimization. This included negotiating a license agreement with PAPRICAN for exclusive use of their related technology. Resulting contracts met or exceeded company guidelines for cash flow and profitability.

Provided leadership, as Project Manager, for CFD analysis of a variety of industrial applications. At the time, this was a critical role given high turnover in this department.

1995 - 1997 **Manager, Industrial and Service Project Engineering**
Babcock & Wilcox, Cambridge, Ontario

Primary areas of responsibility included proposal and design activities for Babcock & Wilcox Canada's service project.

Managed B&W Canada R&D plan. Single point liaison with US R&D organizations.

Managed contract and R&D performance testing for International projects.

1991 - 1995 **Manager Field Engineering & Technology**
Babcock & Wilcox, Cambridge, Ontario

Key areas of responsibility included managing commissioning and testing efforts for projects on a global basis. Developed cost estimating standards and cost control systems for commissioning and testing work.

Co-ordinated R&D program. Major initiatives included increased funding from 1- 6 million dollars annually. Developed a review process to justify R&D expenditures based on business needs.

Led Engineering Audits of Joint Ventures in India and China.

Chaired design review committee for first PWR Replacement Steam Generator.

Managed work of Material Engineering, Chemical Cleaning and water chemistry personnel who were extensively involved in Replacement Steam Generator fabrication.

1990 - 1991 **Senior Project Engineer, Utility Retrofits**
Babcock & Wilcox, Cambridge, Ontario

Responsible to co-ordinate technical aspects of Plant Improvement Projects for utility boiler retrofits. This included initial proposal development as well as contract execution.

Major Projects included life extension for four units at Ontario Hydro's Lakeview Generating Station and upgrades to Nova Scotia Power Corporation's Tufts Cove #1 boiler.

1988 - 1990 **Vice-President**
F. H. Theakston & Associates, Guelph, Ontario

Oversaw all aspects of a small consulting firm specializing in scale flow model testing of proposed building design. Prepared microclimatic reports based on test results.

Developed vital business processes including a cost control system, proposal standards and automated report preparation. Created and executed a marketing plan that was successful in increasing business levels.

1987 - 1989 **Supervisor, Proposal Engineering**
Babcock & Wilcox, Cambridge, Ontario

Supervised the activities of an engineering group responsible for the preparation of technical proposals. Delivered technical presentations in support of the sales team. Reviewed and ensured the accuracy of cost estimates.

The Canadian Pulp & Paper market expanded significantly during this period. B&W Canada won approximately 75% of the market including the Howe Sound Chemical Recovery Boiler that remains among the largest units in the world.

1985 - 1987 **Project Engineer**
Babcock & Wilcox, Cambridge, Ontario

Ensured that designed and purchased equipment met the requirements of customer's technical specifications. Performed calculations in support of this effort in the areas of heat transfer, fluid mechanics, structural analysis and thermodynamics.

Was responsible for the design of several first of kind projects including a 15 MW wood fired boiler for Greenville Steam & Power, Greenville, Maine USA and the conversion of a 150 tonnes/hour boiler in Ulsan, South Korea to fire coal water slurry (CWS).

1983 - 1985 **Development Engineer**
Babcock & Wilcox, Cambridge, Ontario

Prepared recommendation and standards relating to boiler and auxiliary equipment. This was routinely done as follow up to the resolution of customer's operating problems. One challenging assignment was to review and develop company design standards for boilers firing high vanadium fuel oils.

Participated as a key member of performance testing teams. Developed software for computer assisted data acquisition and performance diagnostic programs.

Assisted New Brunswick Electric Power Commission's initial review of orimulsion firing at Coleson Cove Generating Station.

1982 - 1983 **Proposal Engineer**
Babcock & Wilcox, Cambridge, Ontario

Reviewed technical specifications and determined technical strategy for proposals. Participated in the preparation of cost estimates. Worked on a wide variety of utility and industrial boilers.

1981 – 1982 **Engineering Trainee**
Babcock & Wilcox, Cambridge, Ontario

Received orientation to the company's internal design procedures with particular emphasis on the ASME Power Boiler Code. Participated in cost reduction and product rationalization programs. Prepared ACE documents including technical and financial justifications for proposed capital expenditures.

Specific assignments were to Engineering Technology, Manufacturing Engineering and Proposal Engineering. Specific activities included review of candidate material for Nuclear Steam Generator tube cleaning guides.

APPENDIX B

INDUSTRY PARTICIPANT INFORMATION

babcock & wilcox canada ltd.
581 coronation boulevard cambridge, on n1r 5v3 canada
phone 519.621.2130 fax 519.621.2310 www.babcock.com

September 19, 2008

Saskatchewan Power
2025 Victoria Avenue
Regina, SK
S4P 0S1

cc: Gillian Ash Richard, SaskPower
Don Tonn, B&W PGG
Malcolm Mackenzie, B&W Canada

Attention: David W. Smith
Project Leader, Environmental Initiatives

Subject: Letter of Interest and Commitment for "Long-term Assessment of Selective Catalytic Reduction Reactor Slip Stream Performance for Utilities Burning Northern Lignite Coal" at SaskPower's Poplar River Station

Gentlemen,

Babcock & Wilcox (B&W) is a leading supplier of boilers and Air Quality Control Systems (AQCS) to both the utility and industrial markets. Our experience list includes installations that burn North Dakota and Saskatchewan lignite along with coals from around the world.

B&W invests extensively in R&D supporting our entire line of products including combustion control and selective catalytic reduction (SCR) technologies to reduce NOx emissions.

Please consider this submission as B&W's letter of commitment for subject slip stream SCR NOx reduction project at SaskPower's Poplar River Station.

The boilers at Poplar River combust the same coal as burned at other sites where NDIC has supported both slipstream and full-scale projects on controlling mercury emissions.

The proposed work of this project addresses issues identified in a previous NDIC-supported project where slipstream SCR tests were done at three low rank coal-fired power plants, including Otter Tail's Coyote Unit 1 burning Beulah-Zap lignite. In that work low temperature deposition of mineral matter led to catalyst blinding and pluggage problems.

B&W has followed the previous work done by others to evaluate the application of catalyst to Lignite coals. Based on B&W's experience with slip stream SCR, we feel there is more to be learned. We have therefore included further work in our R&D program with the expectation that the planned two year test duration will provide a good indication of the sustainability of SCR performance over the long term.

Our background with many commercial full scale SCRs plus previous SCR slip stream evaluations, all with other fuels, provides a sound design basis for both the slip stream reactor and test program for SaskPower.

B&W's commitments to this project are estimated to have a value of $150,000 and are outlined in our executed host site agreement with SaskPower. B&W's contributions to this project include:

- Overall technical coordination of the program;
- Development of the detailed test plan;
- Design and supply of the slipstream SCR reactor as indicated in our agreement with SaskPower.

B&W looks forward to participating in this interesting and worthwhile project that will develop SCR technology for application to low rank coals such as the lignite that is used in both North Dakota and Saskatchewan.

Yours truly,

Ron Ojanpera
Manager, Environmental Systems